SF06

Machine Safety Solutions Overview

SOLUTION EXPO TRAINING & PRODUCT SHOW

Welcome

During this session we will discuss various types of safety devices available for machinery safety solutions to prevent access to or control a hazard.

We will include products from Rockwell Automation, Numatics and Paletti.

Rockwell Automation numatics Paletti

Additional discussion is available in these sessions:

- SF01 – Risk and Hazard Assessment
- SF02 – Introduction to ISO 13849
- SF04 – Guard Interlocking Update ref ISO 14119
- SF05 – Configurable Safety Relay Lab with 440R-CR30

Does it really matter which device?

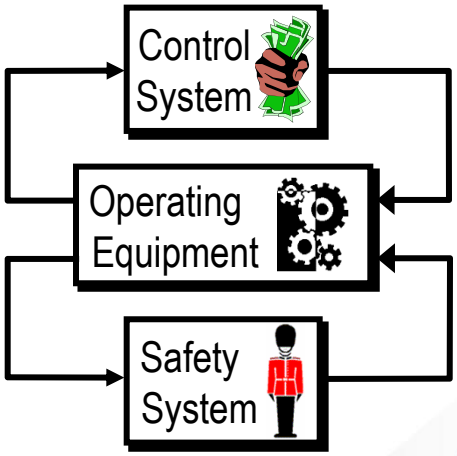
A machine control strategy that includes both safety and production control systems?

- Purpose of production system is to *produce*
- Purpose of safety system is to *protect*

In the past, safety and production control systems shared little, if any information

Harmonizing your safety and production control systems offer tremendous opportunities to improve productivity

- Shared diagnostics on common HMI for faster troubleshooting
- Safety system that changes parameters based on the state of the production system
- Zone control to enable continued production flow when one zone is shut down
- Better shut down and restart of production systems after a safety event



When do you select hardware?

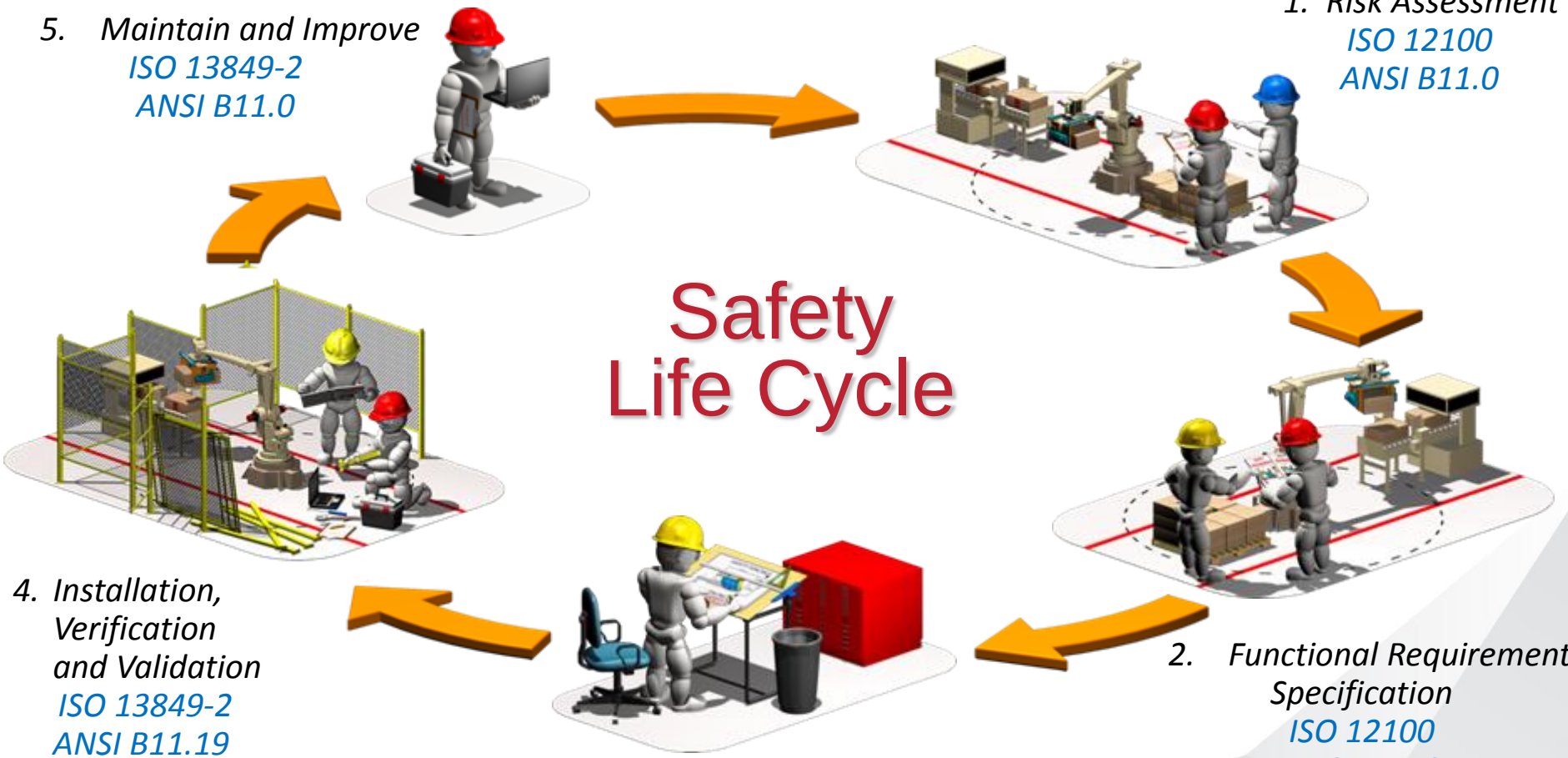
1. *Risk Assessment*
   ISO 12100
   ANSI B11.0

2. *Functional Requirements Specification*
   ISO 12100
   ANSI B11.0

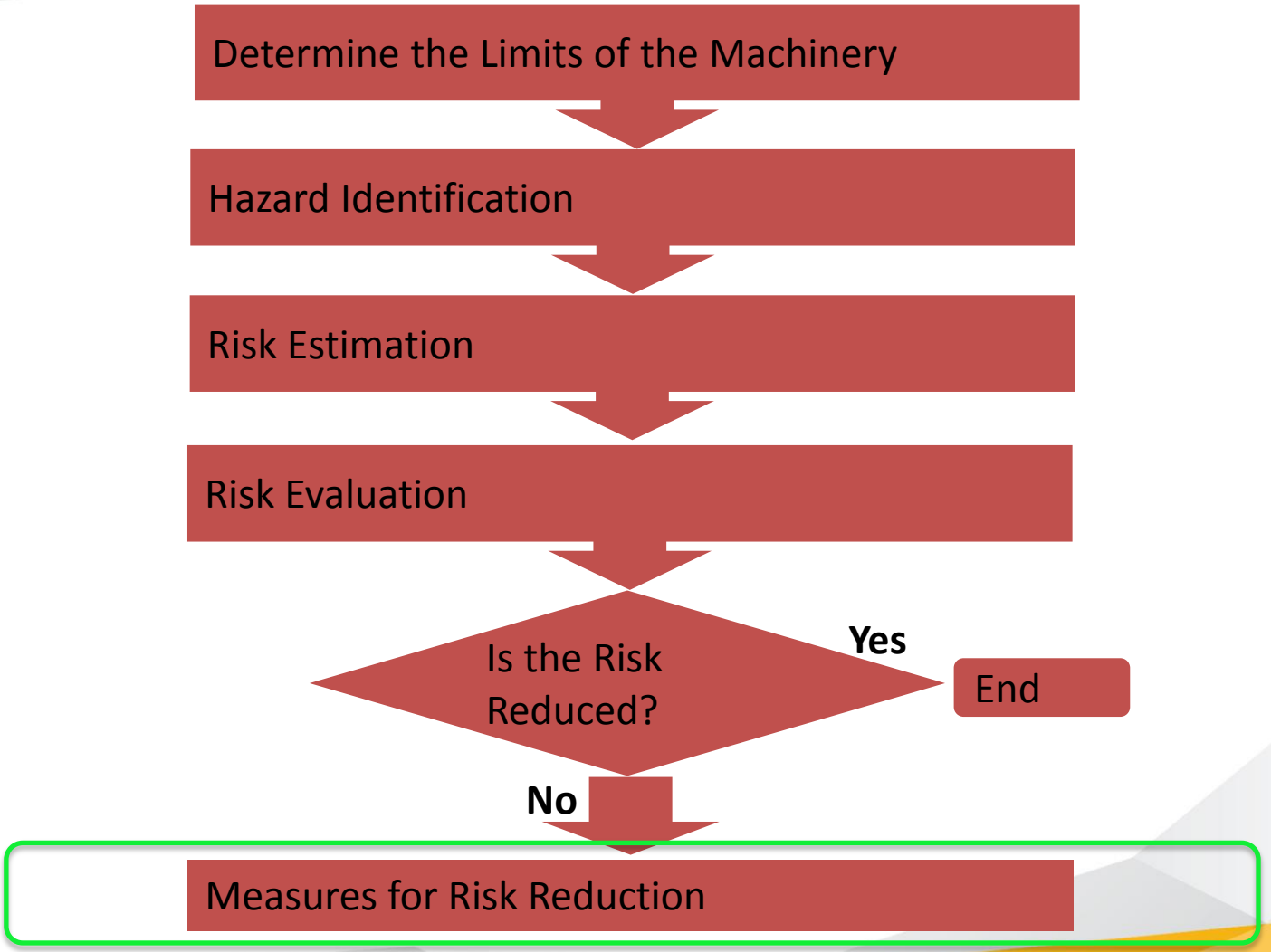
3. *Design and Design Verification*
   ISO 13849-1
   ANSI B11.19

4. *Installation, Verification and Validation*
   ISO 13849-2
   ANSI B11.19

5. *Maintain and Improve*
   ISO 13849-2
   ANSI B11.0

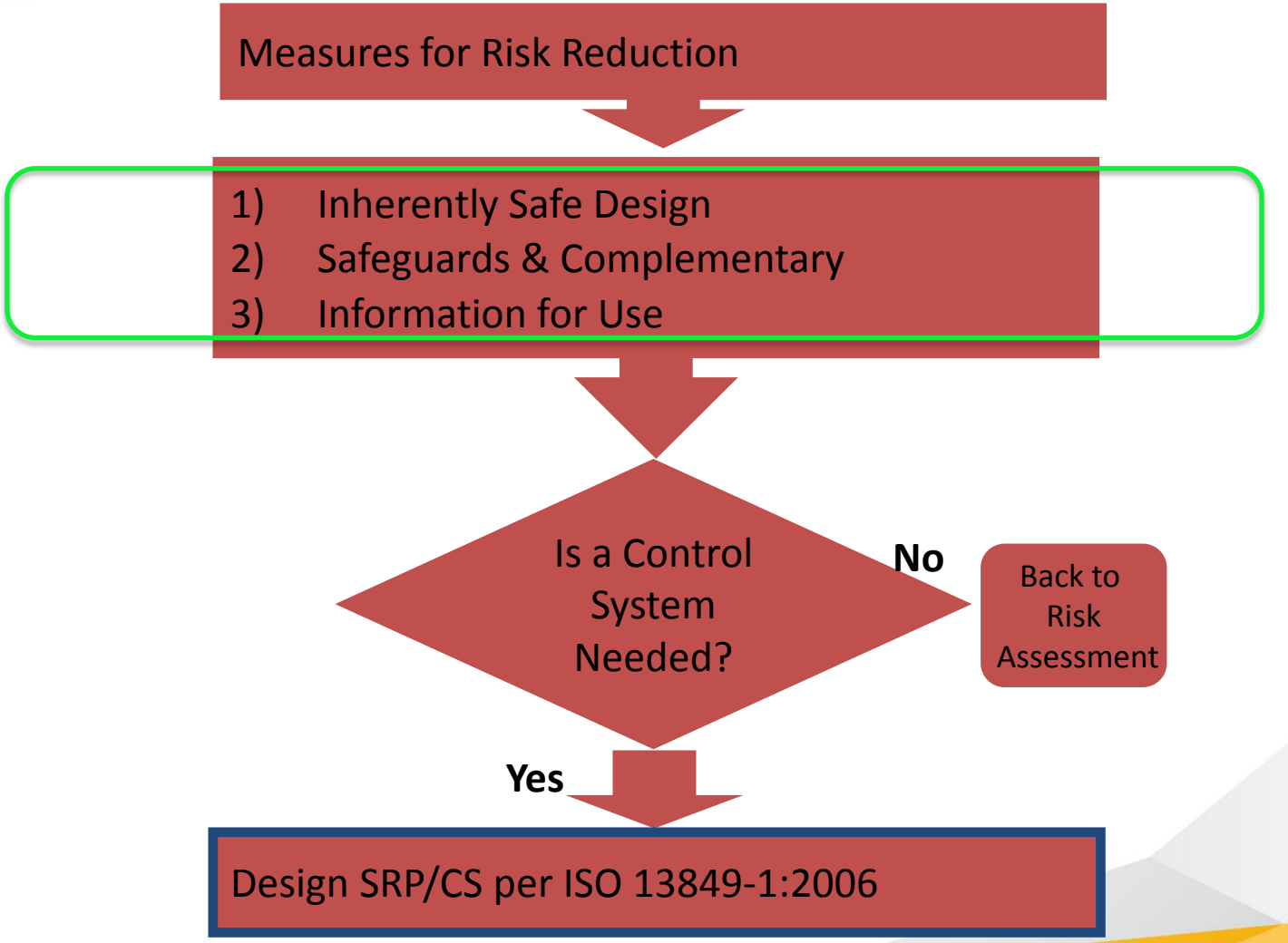


Risk Assessment Overview



Refer to SF01 – Risk and Hazard Assessment for more information on this process.

Risk Reduction Overview



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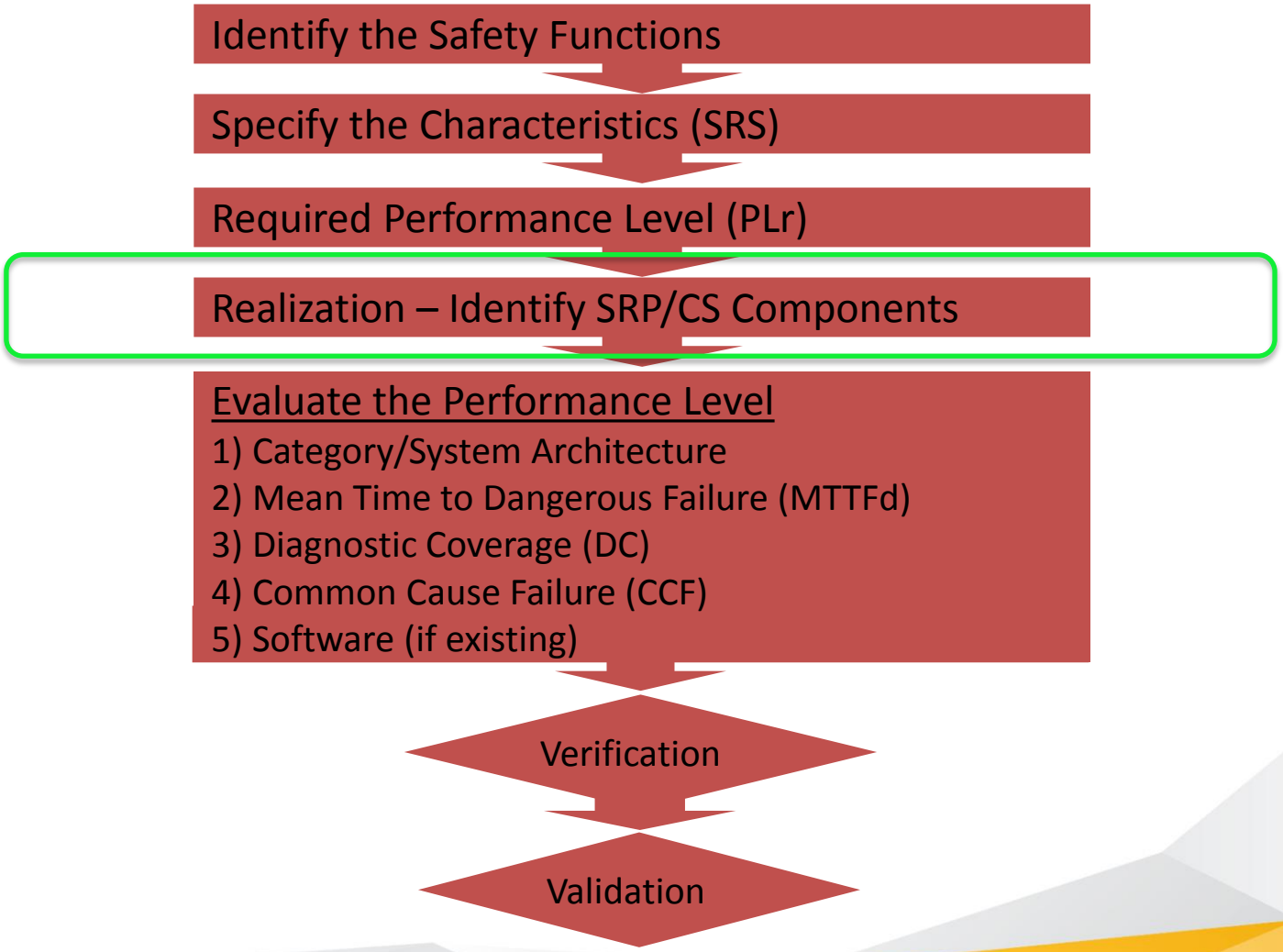
SRP/CS Design Overview



Safety Requirements Specification

- The Safety Requirements Specification (SRS) is a formal document which describes the various safety functions and provides all of the required information an engineer will need to design the control system to perform the safety functions.
- The SRS is considered a living document and shall have provisions for revision control and document management.
- The validation protocols for testing the safety functions are derived from the SRS.
- The SRS should include the following: Description of the function, environmental requirements, response times, operating modes, fault handling requirements, diagnostics, safe parameters, fault exclusion, failure modes, etc.

Six Steps to Performance Level

Once the Safety Functions have been identified and defined, there are six basic steps required to determine the Performance Level.

Step 1 – Determine the required performance level (PLr)

Step 2 – Identify the SRP/CS Components & Design Block Diagram

Step 3 – Evaluate the Performance Level (PL)

- **Step 3a** - Category
- **Step 3b** - Mean Time to Dangerous Failure (MTTFd)
- **Step 3c** - Diagnostic Coverage (DC)
- **Step 3d** - Common Cause Failure (CCF)

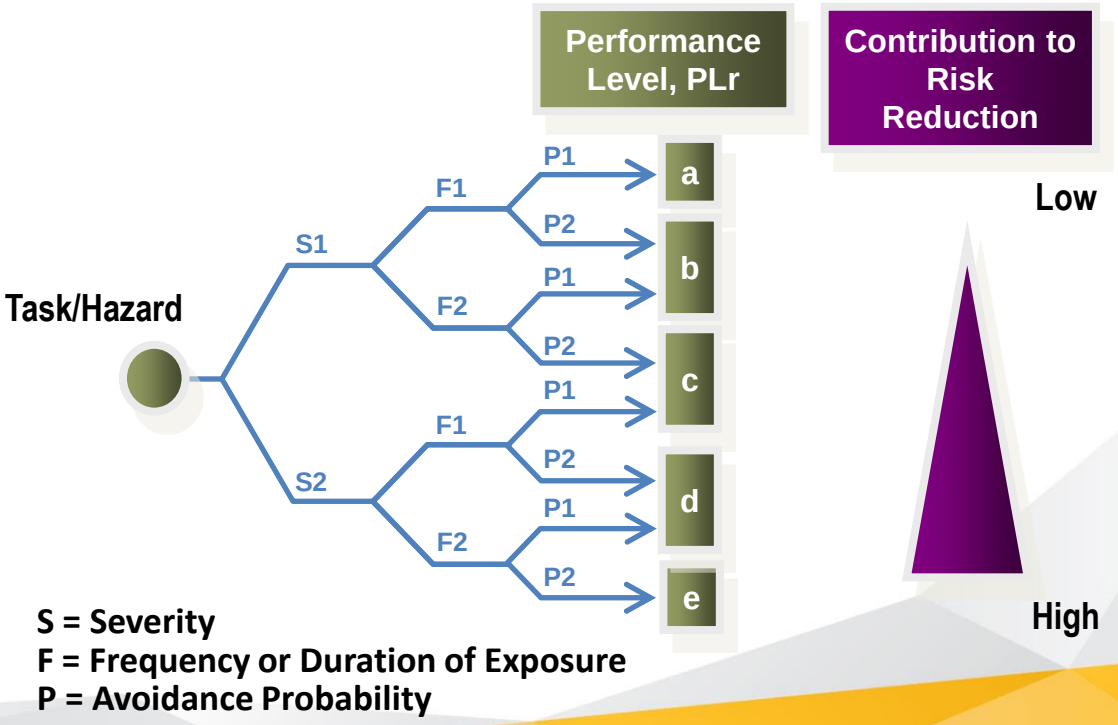
Step 4 – Develop Safety-Related Software (If Required)

Step 5 – Verification of Performance Level (PL $\geq$ PLr)

Step 6 – Validation that all requirements are met

Performance Level Required

- The Risk Assessment determines the Performance Level required, PLr
- Creates the Foundation of the Safety System Functional Requirements, System Design and Validation Protocol
- Shows “Due Diligence” and compliance to standards



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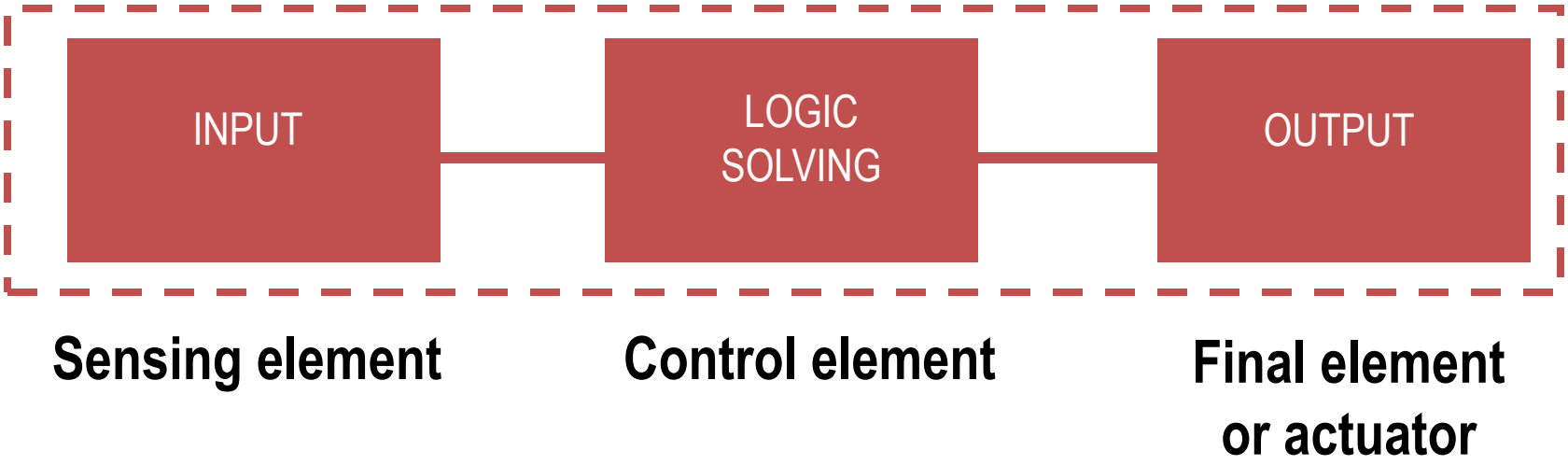
Identify Component & Block Diagram

- Typical safety function diagram:



- The designer shall select an architecture that will meet the needs of the safety function.
  - Category B, 1, 2, 3 or 4

Risk Reduction Hierarchy

Design it out

Fixed enclosing guard

Controlling, Limiting or Monitoring Access

Awareness Means, Training and Procedures (Administrative)

Personal protective equipment

Most Effective

Least Effective

Design it out?

Mechanical and design engineers are integral to the safety process and often the most capable to prevent a hazard.

- Selection of technology
  - Is the technology/device inherently dangerous or safe?
  - Can an alternative technology be used?
- Placement or orientation within the machine
  - Can the hazard be mitigated by redesign?
- Physical characteristics
  - Can a hazard be mitigated through the design of parts?

Risk Reduction Hierarchy

Design it out

Fixed enclosing guard

Controlling, Limiting or Monitoring Access

Awareness Means, Training and Procedures (Administrative)

Personal protective equipment

Most Effective

Least Effective

Safeguard Requirements

- Prevent contact
  - Prevent worker's body or clothing from contacting hazardous moving parts
- Secure
  - Safeguards are firmly secured to machine and not easily removed (require use of tools)
- Protect from falling objects
  - No objects can fall into moving parts

Two Types of Guarding

- **Separating**
  - Fixed fences & barriers require a tool for removal
  - Moveable guarding types require interlock switches

- **Non-Separating**
  - Mechanical detection devices
    - Safety Mats
    - Pressure Sensitive Edges
  - Electro-Sensitive Devices
    - Light Curtains
    - Area Scanners

    require safe distance calculation
  - Localized protection devices
    - Emergency Stops
    - Two Hand Control
  - Moveable protection devices
    - Enabling Switches

Separating Guarding Examples

Fixed Guarding

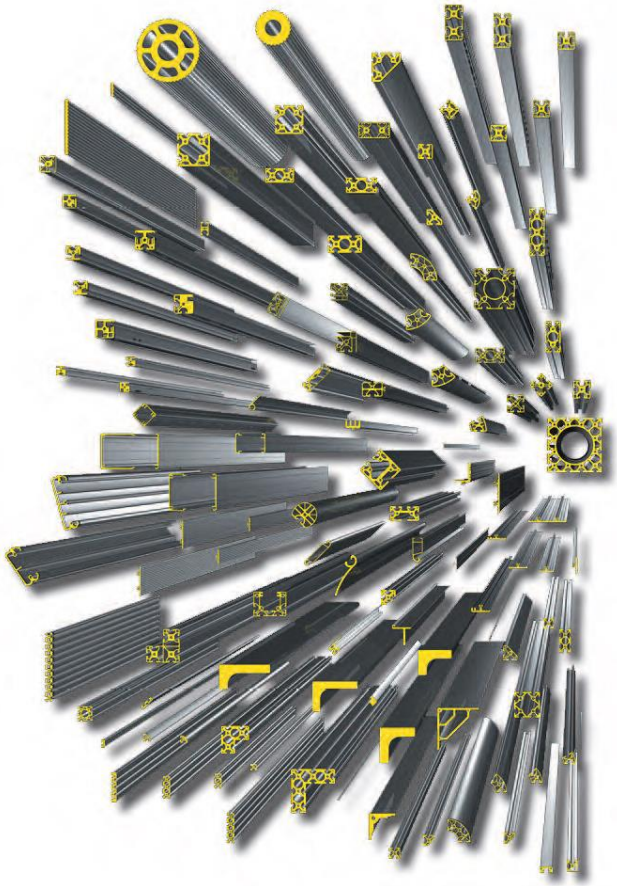
Separating guards provide a physical separation from machine hazards

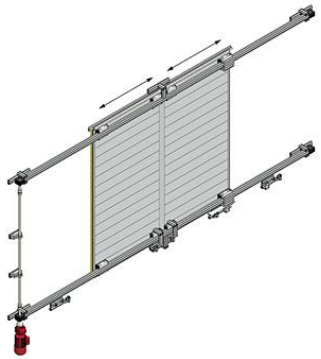
Moveable Guarding

Separating Guard Criteria

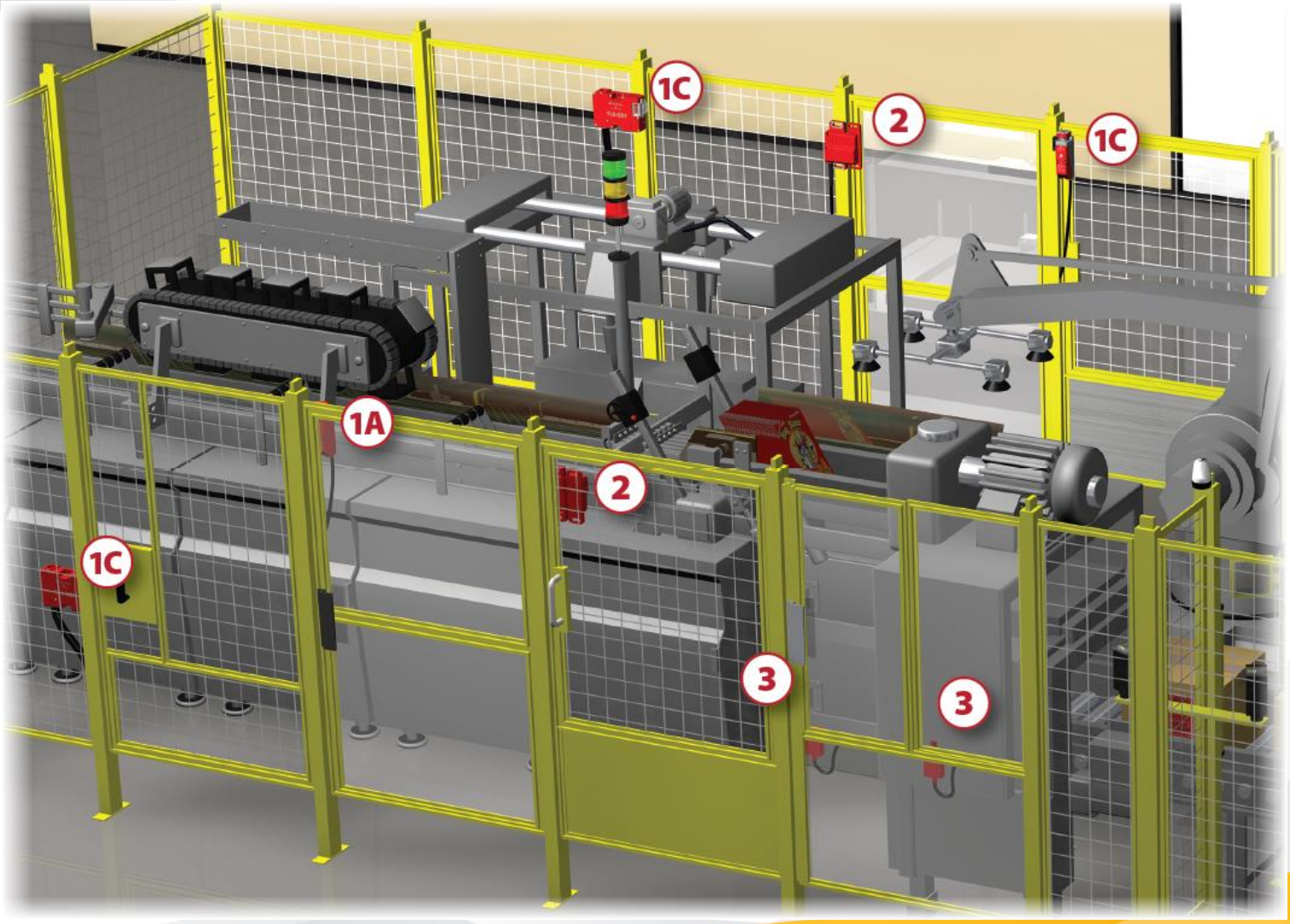
- Is access needed to the protected area?
- How often is access needed?
- What is the hazard?
- How long does it take the hazard to stop?
- Who needs access to the hazardous area?
- Why is access needed?

Paletti Guarding Solutions





Interlocks for Movable Guards?



Tongue Operated Interlocks

Bulletin 440K

- Provide electrical interlocking of a machine's control circuit to the guard door
- Offering flexible keys for enhanced tolerance to misalignment to meet a wide range of applications
- Available in a variety of packages, contact configurations and degrees of holding force
- Easy to install and cost-effective

Non-Contact Interlocks

Bulletin 440N

- Requires no physical contact with the actuator
- No contact between sensor and actuator helps reduce risk of debris contamination
- Large sensing field helps compensate for door misalignment
- Types: RFID coded (standard & unique) and magnetically coded

SensaGuard

The next generation of non contact switches using RFID technology for coding and inductive technology for sensing

- Safety certified to PLe and Cat. 4
  - EN/ISO 13849-1
  - EN/ISO 14119:2013
- Solid state design and monitored outputs allows series connections
- Scalable protection with Unique or Standard coded RFID actuators
- Plastic or stainless steel housing
- IP69K washdown rating
- High tolerance to misalignment
- Output/Diagnostic LED on the sensor

Guard Locking Interlocks

Bulletin 440G

- Provide electrical interlocking of a machine's control circuit to the guard door
- Ideal for applications that require a guard door to remain closed and locked until potential hazards have stopped or come to a predetermined safe state
- Cost-effective solution for protecting machines from interruptions in production

Guardmaster 440G-LZ

- Safety certified to PLe and Cat. 4
  - EN/ISO 13849-1
  - EN/ISO 14119:2013
- Solid state design and monitored outputs
- Scalable protection with Unique or Standard coded RFID actuators
- High holding force of 1300N (Fzh)
- Energy Efficient Device: only uses 2.5W
- IP69K-rated housing design
- Power-to-Release and Power-to-Lock versions
- Compact design optimized for ease of mounting
- Diagnostic info provided with 2 bright 270° LEDs

Actuator
Metal holding bolt (inserts into the metal bracket and sensor assembly)
440G-LZ
Bar code with URL link to User Manual
LEDs (both sides)
Global approvals
Slim, clean design, sealed body (IP69K)

Solid-state safety design

- With the solid state design these can be connected in series with other devices such as Light Curtains and SensaGuard™ switches while maintaining a PLe rating
  - Exceeds requirements of ISO TR 24119 referenced in the new EN/ISO 14119:2013 standard
- Short circuit protection
- Overload protection
- Cross fault (channel to channel) detection
- Designed to switch DC powered devices
  - Supports switching of up to 200 mA

Hinge Operated Interlocks

Bulletin 440H

- Connect directly to a guard door hinge and allow immediate opening of the guard
- Provides good clearance due to unobtrusive mounting
- Well-suited for machines where product is loaded through a hinged guard
- Ideal for machines with misaligned guards or applications with contaminants

Limit Switch Interlocks

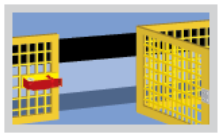
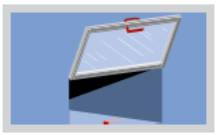
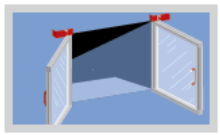
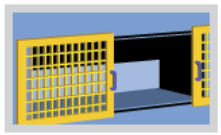
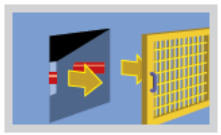
Bulletin 440P

- Available in four different body styles with a broad selection of operators, circuit arrangements and connection options
- 30 mm metal, 22 mm metal and plastic, and 15 mm plastic body styles
- Positive opening-action contacts, making them ideal for safety-related applications

Safety Interlock Guidance

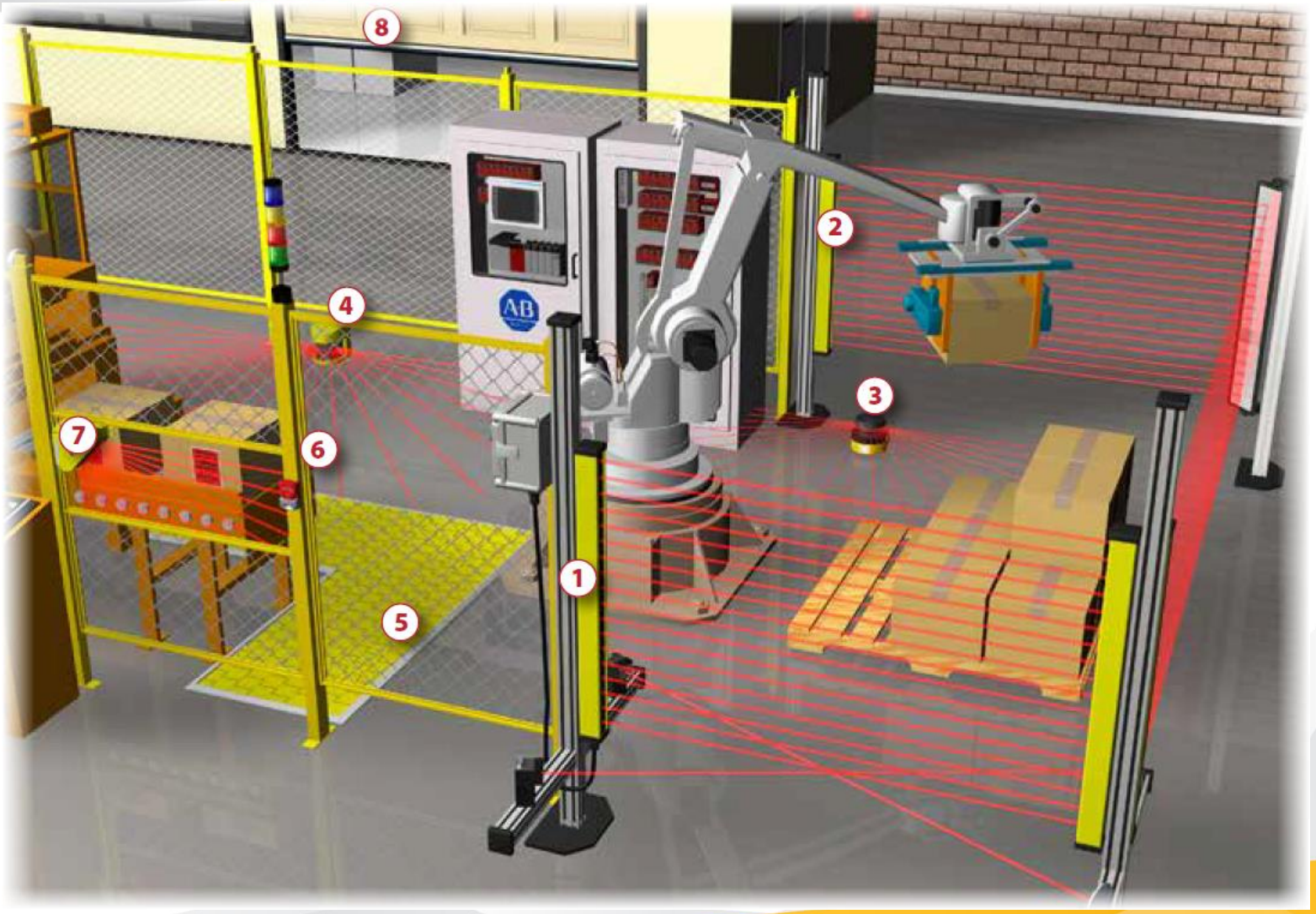
Type of Guard

Recommended Switch Type

	Swinging			Sliding	Removable
					
Tongue	✓	✓	✓*	✓	✓*
Guard Locking	✓	✓*	✓*	✓	✓*
Non-Contact	✓	✓	✓	✓	✓
Hinge	✓	✓*	✓		

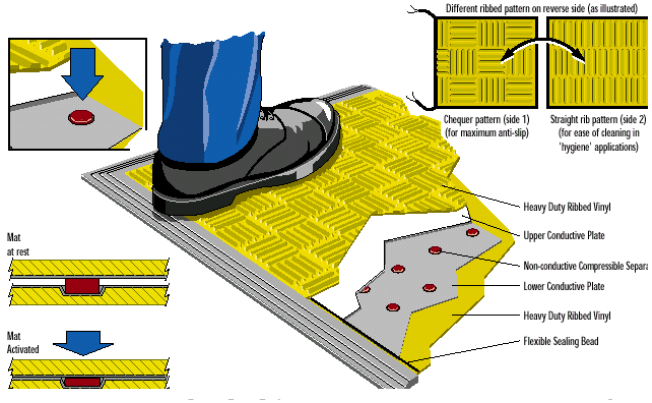
* Depending on mounting

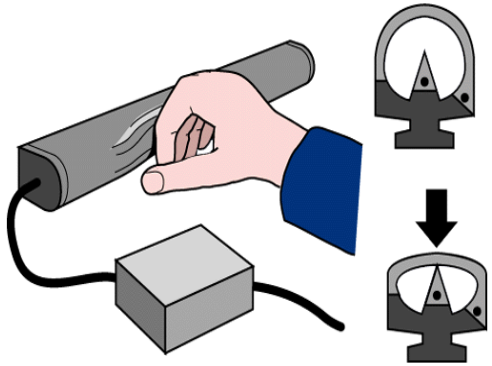
Require Open Access Areas?



Non-Separating Methods

Pressure Sensitive safety systems– This includes safety mats and safe edges.

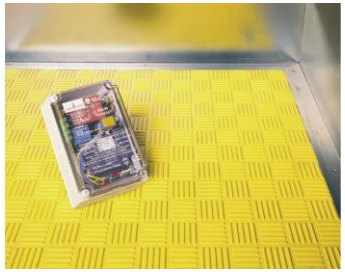

Different ribbed pattern on reverse side (as illustrated)
Chequer pattern (side 1) (for maximum anti-slip)
Straight rib pattern (side 2) (for ease of cleaning in 'hygiene' applications)
Heavy Duty Ribbed Vinyl
Upper Conductive Plate
Non-conductive Compressible Separ
Lower Conductive Plate
Heavy Duty Ribbed Vinyl
Flexible Sealing Bead
Mat at rest
Mat Activated



Electro Sensitive safety systems – This includes light curtains, area scanners and safety cameras.

Pressure Sensitive Devices

MatGuard™ Safety Mats



- Specially hardened steel plate construction
- Active sensing over entire mat surface
- Four-wire system for fault detection
- Minimum detection weight of 66 lbs Variety of aluminum trim options
- Special sizes and shapes are possible
- IP67

Safedge™ Safety Edges

- Conductive rubber profiles
- 5 mm, 19 mm or 41 mm (0.19 in., 0.74 in. or 1.61 in.) cushion factors available
- 50 m (164.04 ft.) maximum lengths
- Variety of profile shapes
- IP65

Light Curtains

GuardShield Type 4

- Advanced features and functionality
- Range: 16 m
- Integrated laser alignment
- Finger 14 mm or hand 30 mm detection
- Cascadeable
- IP65 standard / IP67 kits available

Safe 4

- ON/OFF functionality standard
- Range: 9 m to 30 m
- Integrated laser alignment
- Finger 14 mm or hand 30 mm detection
- IP65

NEW - SC300 Safety Camera

- Compact Safety Camera (Up to 2 meters)
- Expansion of safety light curtain portfolio
- One size fits all - solution
- No software needed
- Easy commissioning with teaching
- 24Vdc, 20ms response time, IP54
- Performance Level d (PLd ISO 13849)
- SIL 2 (IEC 61508)
- Type 3 (IEC 61496)

Presence Sensing Guidance

	GuardShield Type 4	GuardShield Type 2	Safe 4	Safe 2	SC300 Hand Detection Safety Sensor	Micro 400 with MSR41 Controller	Micro 400 with MSR42 Controller	GuardShield Type 4 PAC	Safe 4 PAC	Area Access Control (AAC) Single Beam	SafeZone Safety Laser Scanners	MatGuard Safety Mats	Safedge Safety Edges
Finger Detection	●		●			●	●						●
Hand Detection	●	●	●	●	●	●	●				●		●
Whole Body Detection								●	●	●	●	●	●
Functionality													
Simple On/Off	●	●	●	●	●	●	●	●	●	●	●	●	●
Point of Operation Control (POC)	●	●	●	●	●	●	●				●		●
Point of Access Control (PAC)								●	●		●		
Area Access Control (AAC)										●	●	●	
Advanced Features													
Fixed Blanking	●						●						
Floating Blanking	●						●						
Integrated Laser Alignment	●		●	●				●	●				
Beam Coding	●							●					
External Device Monitoring (EDM)	●	●			●		●	●			●		
Manual Restart	●	●			●		●	●		●	●	●	
Auxiliary Output	●	●					●	●					
Cascading *Single Light Curtain can safeguard two adjacent points of entry*	●					●	●						
Muting *Requires an external module, MSR42 or MSR22LM*	●	●	●	●	●		●	●	●	●	●		

Other Non-Separating Devices

Localized safety systems such as emergency stop pushbuttons, pull-cords, two hand control stations and emergency switching off devices

Movable safety systems such as enabling switches and pendants

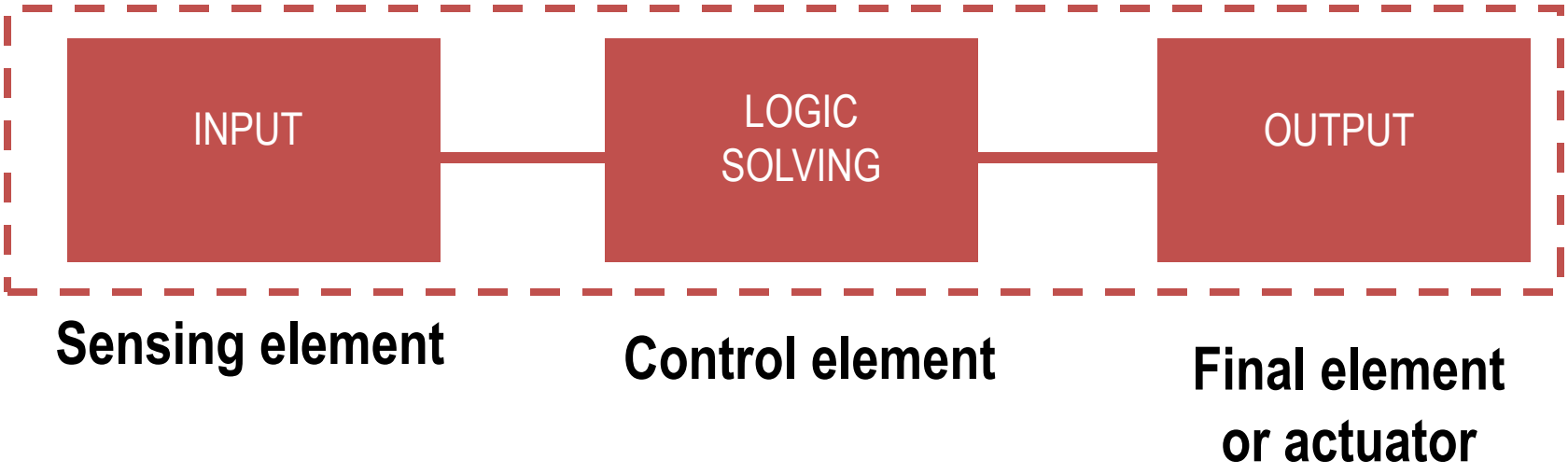
NEW - MobileView

A new portable, tethered EOI device

- HMI Applications with line of sight requirements
- Setup/calibration activities where an operator needs to be in close proximity to application with access to HMI
- Applications requiring local safety functionality through E-STOP or enabling switch
- Maintenance applications

Identify Component & Block Diagram

- Typical safety function diagram:



- The designer shall select an architecture that will meet the needs of the safety function.
  - Category B, 1, 2, 3 or 4

Logic System Considerations

1. Performance Level, Category or SIL level requirement
2. Functional Requirements
3. Control requirements
4. System size / footprint
5. System complexity – Logic Requirements
6. Process complexity
7. Zoning requirements
8. Safety Monitoring / Diagnostics / Information Needs
9. Documentation, Validation, Reporting
10. Cost

Logic System Design

Goal:

The process of specifying and selection of safety systems to deliver compliant machinery to meet safety standards.

Challenge:

Deliver a compliant system without compromising the production capability and flexibility of the overall system.

Deliver a system with capability for expansion and upgrading.

Deliver a system with global support capability

Deliver a system with adaptability and scalability

Design for Recovery - Minimize MTTR – Downtime or Service time

Guardmaster Safety Relays

Universal Input

- A single catalog number to support all types of safety components including e-stops, switches, mats and light curtains
- Six part numbers will cover a majority of safety applications with consistent wiring

Single-Wire Safety Connection

- TÜV approved concept of one-wire connection to expand and cascade safety functions to SIL3
- Simplifies wiring
- Maintains PLe , SIL3 rating

Dual Input Modules

- Twice the functionality of a standard relay in a 22.5mm housing

EtherNet/IP Interface

- Provides status communication with Logix PAC, eliminating multiple wiring terminations

Scalable platform to address single- and multi-zone applications for a variety of standard and special functional requirements

Guardmaster 440C-CR30

Safety made Simple & Flexible

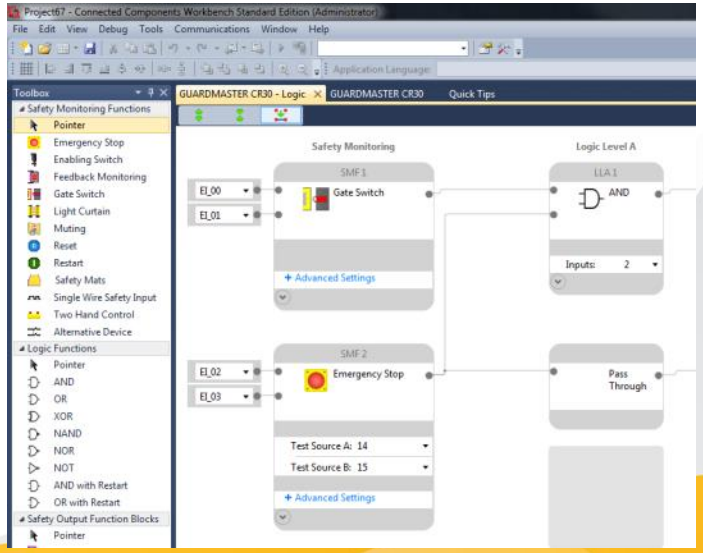
- Supports four to nine dual channel input circuits and up to five safety output zones
- Flexible configuration allows you to re-engineer and rapidly integrate application withou having to incur high costs of rewiring
- Innovative safety logic editor reduces the friction involved in setting up a safety system b minimizing manual input for a “best-in-class” configuration experience

Safety & Productivity

- Embedded serial port for direct diagnostic communications to PanelView Component terminals or Micro800™ controllers
- 16 user configured status LEDs allow you to tailor indication to best suit your application

Optimize Panel Space

- 22 Safety I/O in a compact 110mm wide housing
- Expand by up to 16 standard I/O using front mounted plug-in slots that allow you to maintain the 110mm horizontal footprint



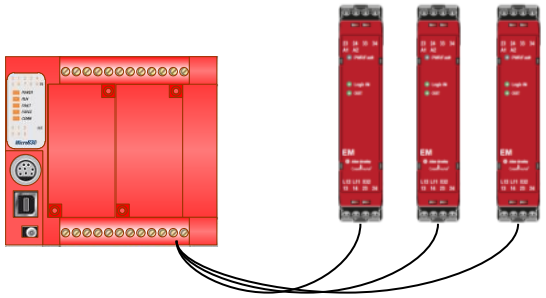
Part of the Connected Components Workbench™ Bundle

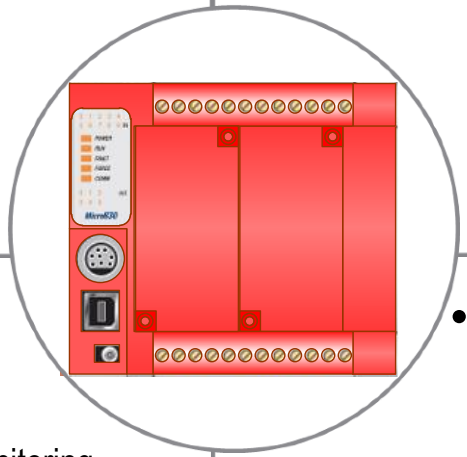
- Preferred compatibility within the bundle
- Reduced supply chain costs
- One software supports Guardmaster 440C-CR30, Micro800 controllers, PowerFlex® drives, Kinetix™ 3 servo drives and PanelView™ Component terminals

Guardmaster 440C-CR30

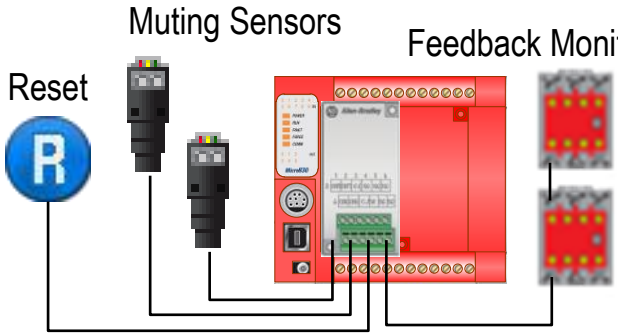
- **Easy to Use**:
  - Innovative rapid configuration editor

- **Single Wire Safety support**:
  - A single wire to expand safety I/O

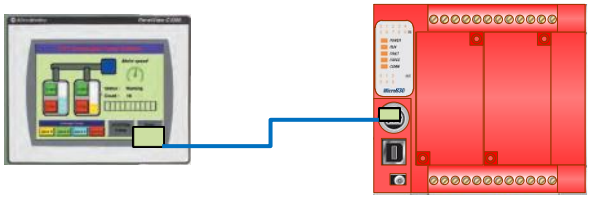




- **2080 Plug-in support**:
  - Expansion of standard I/O



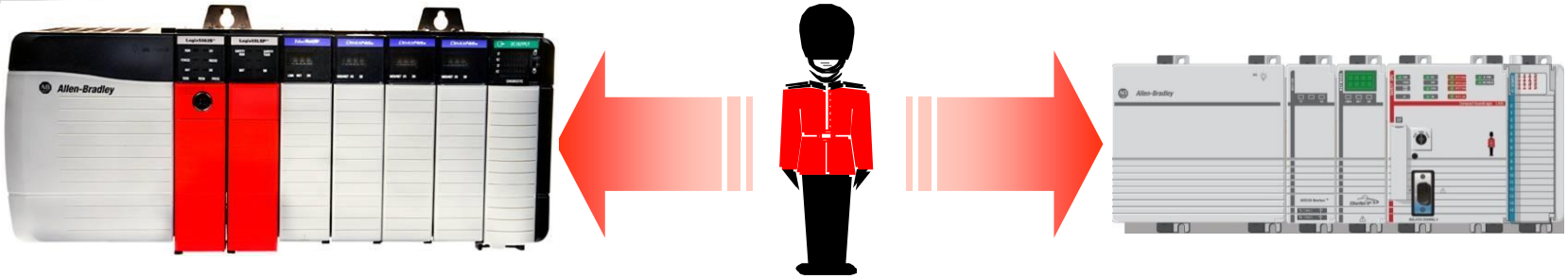
- **Serial Port for Diagnostics**
  - PanelView Component or Micro800



When do use Safety PAC's?

- Where a safety relay or controller isn't quite enough
  - Some complex logic required
    - Light curtain muting plus enable pendant for a zone
  - Multiple safety zones (3 or more)
  - Distributed safety I/O required
- Where a new machine is being built
  - Safety, Motion and standard I/O can be controlled by one controller
- When a modular & scalable system is needed
- When the system has complex needs
- When a large area/footprint is to be safe-guarded

GuardLogix Safety Integration



- **Logix Integrated Safety**
  - Dual Processor Solution (1oo2 Architecture)
    - 1oo2 is recognized as the best safety architecture
  - SIL-3 Certification per IEC 61508
  - ISO 13849 Performance Level e (Category 4)
  - Programs with RSLogix5000
    - Extensive suite of certified safety application instructions
      - Simplifies design, validation, maintenance
      - Dual Channel Suite
      - Muting & Press Suite
  - CIP Safety for safety rated interlocking or safety I/O on Ethernet

Output Device Considerations

1. What type of device needs to be isolated?
2. What type of power needs to be isolated?
3. What is the current requirements of the output device?
4. Where are the outputs located?
5. Is speed control needed?
6. Is position control needed?
7. Is signal control needed?
8. Hardwired or network control?
9. On-machine quick disconect solution?
10. Cost

Safeguarding Output Solutions

- Safety output devices include a number different technologies & solutions that include:
  - Safety Contactors
  - Safety Variable Frequency Drives (VFD's)
  - Safety Servo Systems
- Safety output devices could also include several wiring methods.
  - Hardwired safety systems
  - Networked safety systems
  - On-machine quick connect systems

Safety actuators/output devices

Safety Contactors

- Mechanically linked, positively guided and Mirrored contacts
- Feedback circuit for safety integrity
- Range of power ratings

PowerFlex AC drives

- PowerFlex AC drives with optional integrated safety functions
- Advanced safety functions in PowerFlex 750 series AC drives
- May replace the need for safety contactors
- Remove torque without powering down machine
- Restart machines faster

Kinetix Servo drives

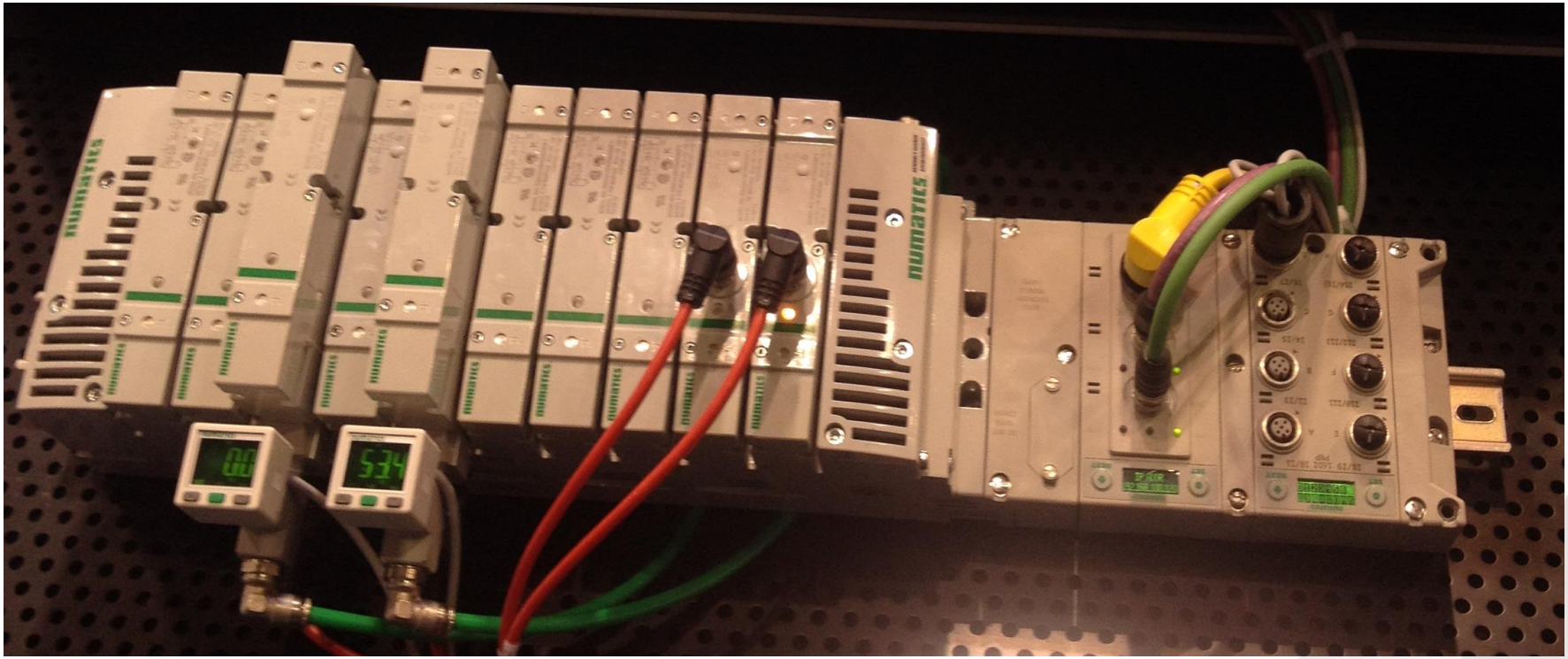
- Kinetix 6000 with optional integrated safety functions
- Safe Torque Off and advanced safety
- Remove torque without powering down machine
- Restart machines faster

Pneumatic and Hydraulic Systems

These valves meet Cat3 and Cat4 requirements and are used in safety solutions to control pneumatic & hydraulic hazards.

Numaitcs Zone Safety

Series 503 valves with G3 communications



Numatics Zone Safety

https://www.youtube.com/watch?v=-x4TQVU20eI

You can see this technology at work in booths 705 and 804 in the tradeshow area.

Questions

???

Alternative Safety Means

ElectroGuard Systems

Trapped Key Systems

Sometimes tradition safeguarding methods are not enough or cannot meet the environmental requirements so there are additional methods that can be used.

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ElectroGuard System Description & Uses

What is an ElectroGuard system? It is a energy control and isolation solution that provides a systematic method of control.

An ElectroGuard system uses safety rated contactors, safety rated pneumatic valves and safety rated hydraulic valves to isolate the energy sources. Pressure switches and voltage meters are used to verify that the energy sources have been removed and safety relays to verify that the correct actions have been taken.

Where do you use ElectroGuard systems?

ElectroGuard systems are used in areas where lock-out & tag-out are complex, spread out, distributed or takes multiple steps.

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Trapped Key System Description & Uses

What is a trapped key system? It is a safety solution that uses keys to ensure a that energy sources and access points are isolated prior to access.

The trapped key system uses a sequence of captive keys, switches, valves, interlock devices and simple control solutions to isolate energy sources.

How do trapped key systems work?

Trapped systems use keys that are captive when the isolation device is in the on position. Keys can only be removed when hazardous energy is removed.

How can trapped key solutions handle complex system requirements?

Trapped key solutions use a building block approach.

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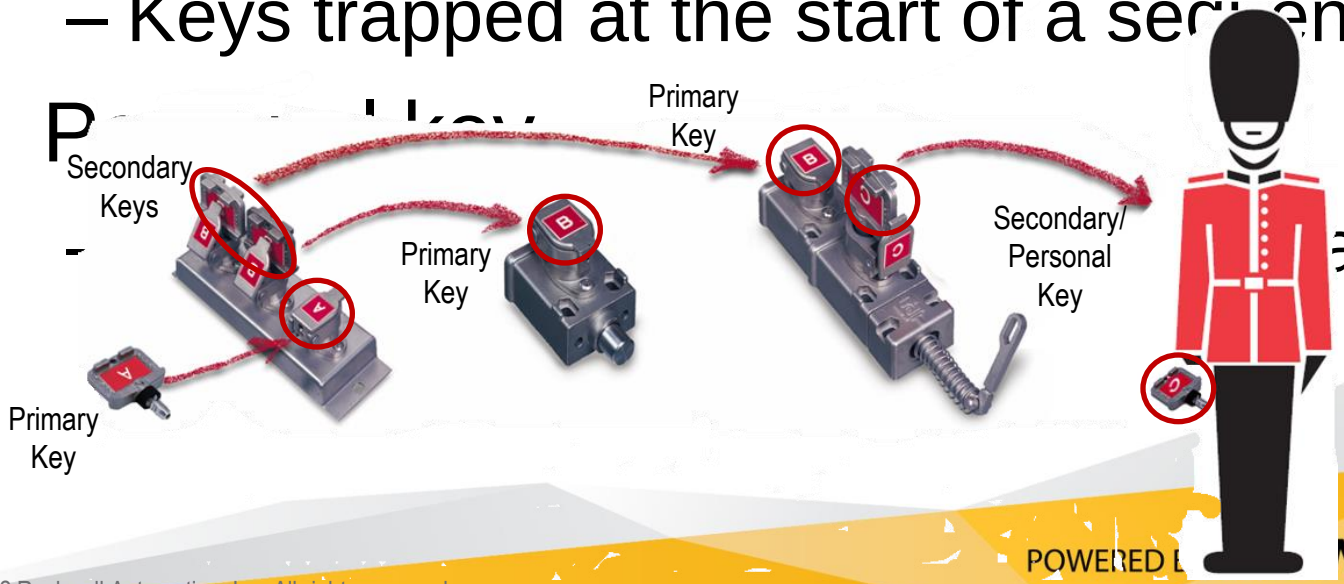
Common Terminology

- Trapped Key Interlock – also known as key transfer systems
- Primary
  - Keys free at the start of a sequence
- Secondary
  - Keys trapped at the start of a sequence
- P[illegible] key
  - [illegible]arried by



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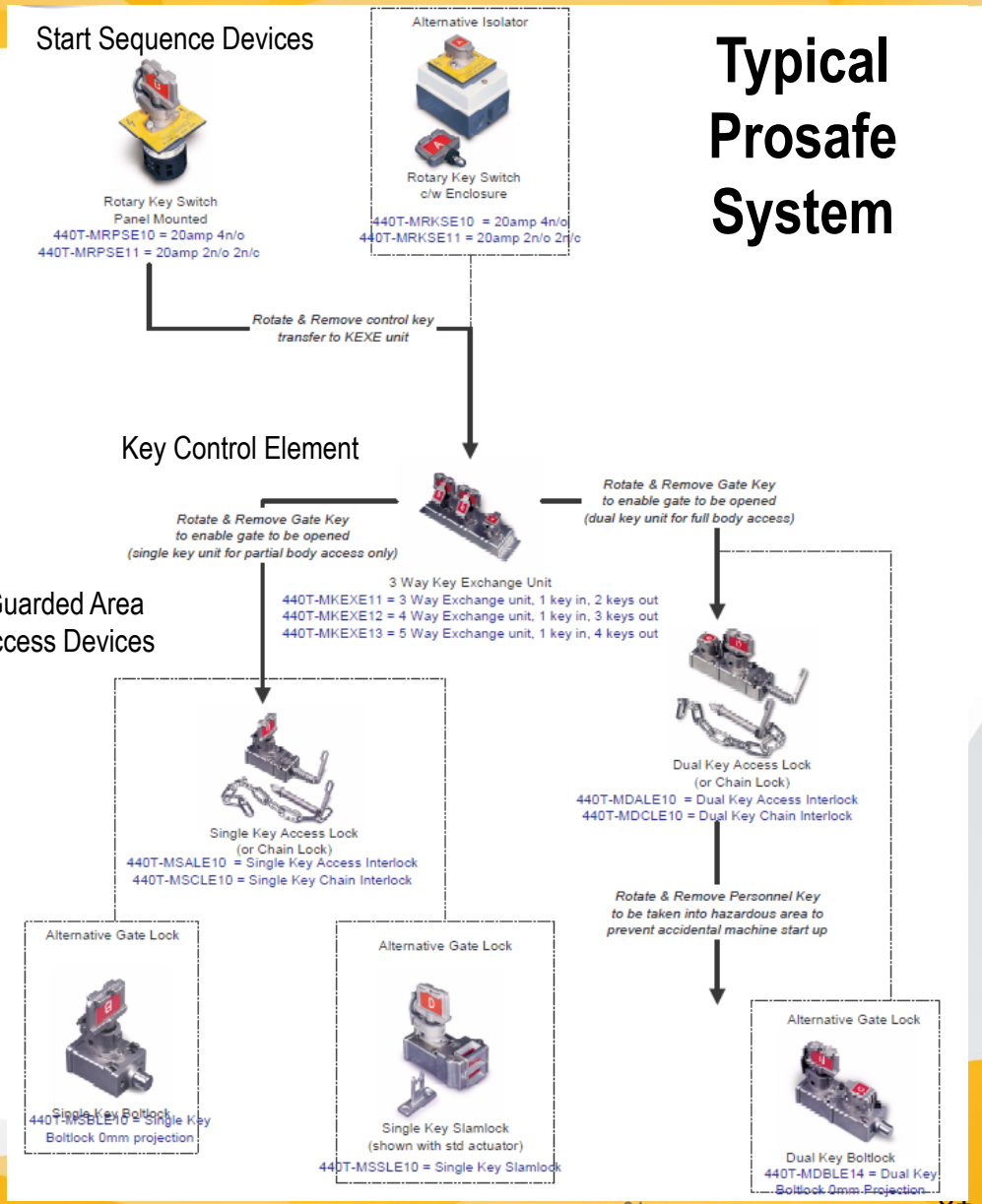
Prosafe Products

- Start Sequence Devices
  - Rotary Switches
  - Solenoid Release
- Key Control Element
  - Key Exchange Units
- Guarded Area Access Devices
  - Bolt Lock
  - Access Locks
  - Slam Locks
- Specialty Devices
  - Electronic Timed Delay Unit
  - Stopped Motion Unit
  - Mini Valve Locks
  - Switchgear Adaptors


Typical Prosafe System
Start Sequence Devices
Alternative Isolator
Rotary Key Switch c/w Enclosure
440T-MRKSE10 = 20amp 4n/o
440T-MRKSE11 = 20amp 2n/o 2n/c
Rotary Key Switch Panel Mounted
440T-MRPSE10 = 20amp 4n/o
440T-MRPSE11 = 20amp 2n/o 2n/c
Rotate & Remove control key transfer to KEXE unit
Key Control Element
Rotate & Remove Gate Key to enable gate to be opened (dual key unit for full body access)
Rotate & Remove Gate Key to enable gate to be opened (single key unit for partial body access only)
3 Way Key Exchange Unit
440T-MKEXE11 = 3 Way Exchange unit, 1 key in, 2 keys out
440T-MKEXE12 = 4 Way Exchange unit, 1 key in, 3 keys out
440T-MKEXE13 = 5 Way Exchange unit, 1 key in, 4 keys out
Guarded Area Access Devices
Dual Key Access Lock (or Chain Lock)
440T-MDALE10 = Dual Key Access Interlock
440T-MDCLE10 = Dual Key Chain Interlock
Single Key Access Lock (or Chain Lock)
440T-MSALE10 = Single Key Access Interlock
440T-MSCLE10 = Single Key Chain Interlock
Rotate & Remove Personnel Key to be taken into hazardous area to prevent accidental machine start up
Alternative Gate Lock
Alternative Gate Lock
Alternative Gate Lock
Single Key Boltlock
440T-MSBLE10 = Single Key Boltlock 0mm projection
Single Key Slamlock (shown with std actuator)
440T-MSSLE10 = Single Key Slamlock
Dual Key Boltlock
440T-MDBLE14 = Dual Key Boltlock 0mm Projection

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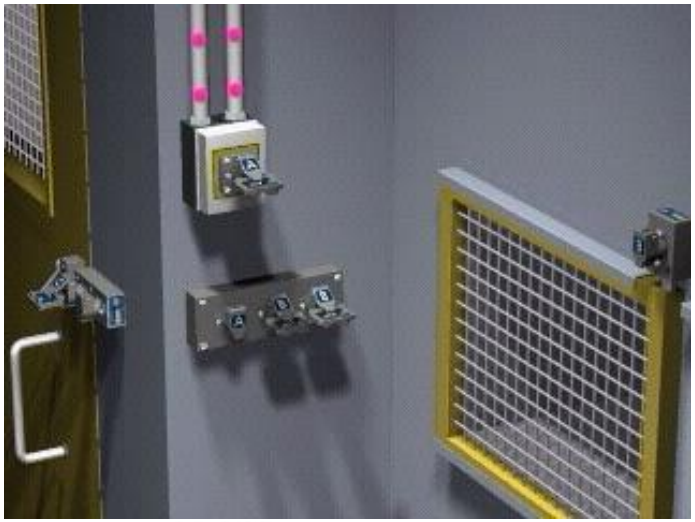
Application Example

- Customer has two gates that need to be accessed
  - On occasion, both gates will need to be accessed at the same time
    - One gate will allow full-body access
    - One gate will only allow top body access (reach in with hands)
- Power must be removed from the hazards prior to opening either gate



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